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STORAGE

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P9S 1903.5

GIFT OF

Univ.

The Mietz and Weiss Kerosene Engine University of Pennsylvania 1903

L.C. Manz.

E 378.748
POS 1903.5

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The object of the test was to determine the indicated horse power, brake horse power, mechanical efficiency, and the oil consumption per 1 H.P.Hr. and B.H.P.Hr of the Metz and Wiess Kerosene Engine, when running under various loads.

The engine as seen from the accompanying photographs p.p.5-6 Is of the horizontal type of the following dimensions:--

Bore of cylinder [illegible], 6"

Stroke 8".

Length of connecting rod 2 1/2 x stroke--20".

Crank radius 4".

Exhaust port opening 1 1/2" measuring from the end of the piston when the latter is at the forward centre.

Opening of the suction port through which air is passed into the crank case -- 1 1/2".

Opening of the air inlet port over the piston- 7/8".

Igniter ball (inside diameter) - - 2 3/4".

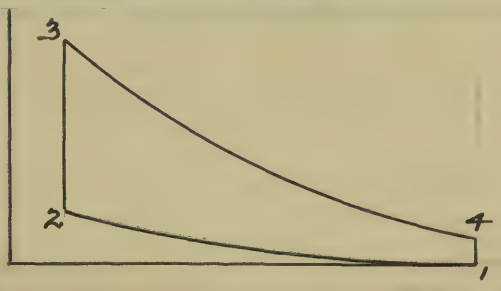
The engine is rated at 8 H.P. when running at 360

30 Aug '48. St. L. Univ. M. Louis Christian

r.p.m., the oil consumption rating being at 1 pint per 1 H.P. Hr.

It operates on the two cycle principle, which provides for one explosion every revolution, or two complete strokes.

The cycle really consists of six operations, four of which are shown on the card.



FIRST:- Compression of the mixture in the clearance space on the return stroke of piston along line 1 - 2.

SECOND:- Exploding the charge along 2 - 3.

THIRD:- Expanding the heated gases along 3 - 4, on the forward stroke of piston.

FOURTH:- Escape of the burned gases into the atmosphere along 4 - 1.

The remaining two operations which are not shown on the card, are taken care of in the crank case, and are

as follows:-

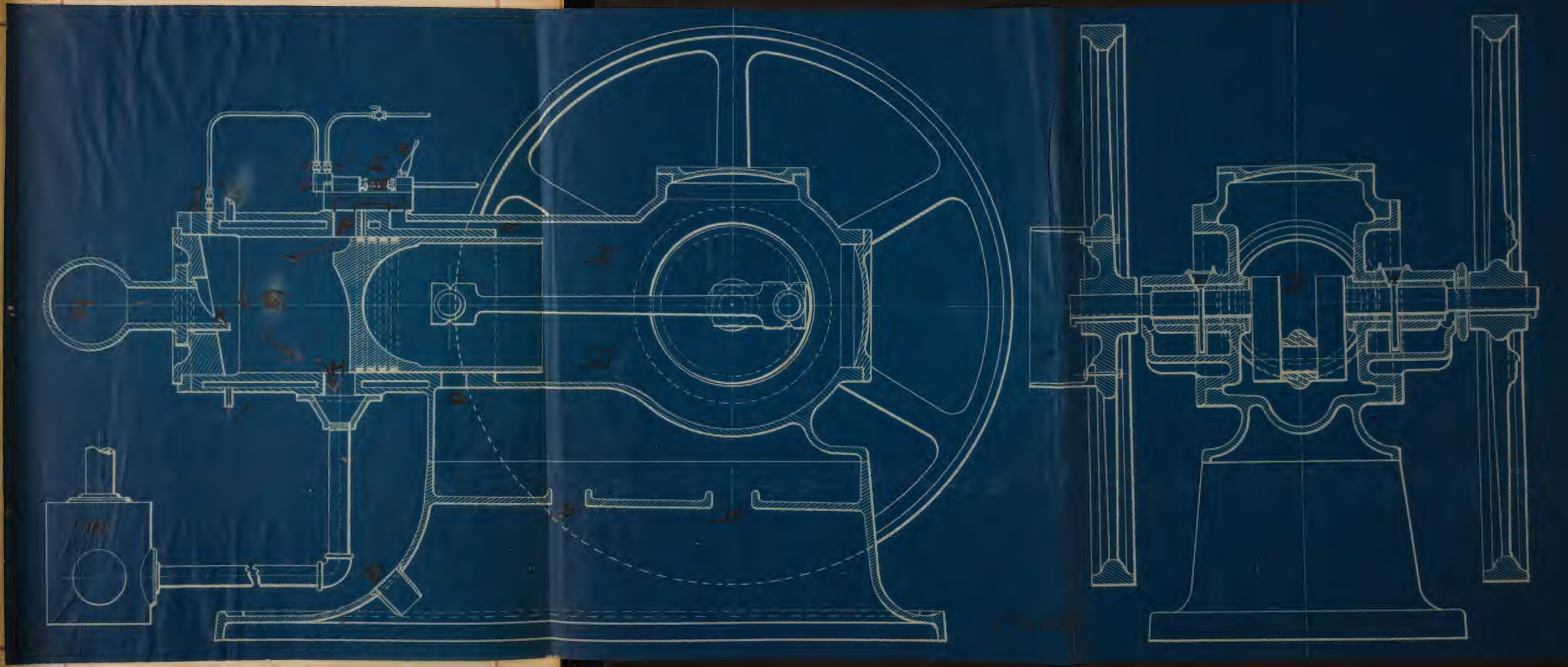
FIRST:- Drawing in a charge of air into the crank case on the forward stroke of the piston.

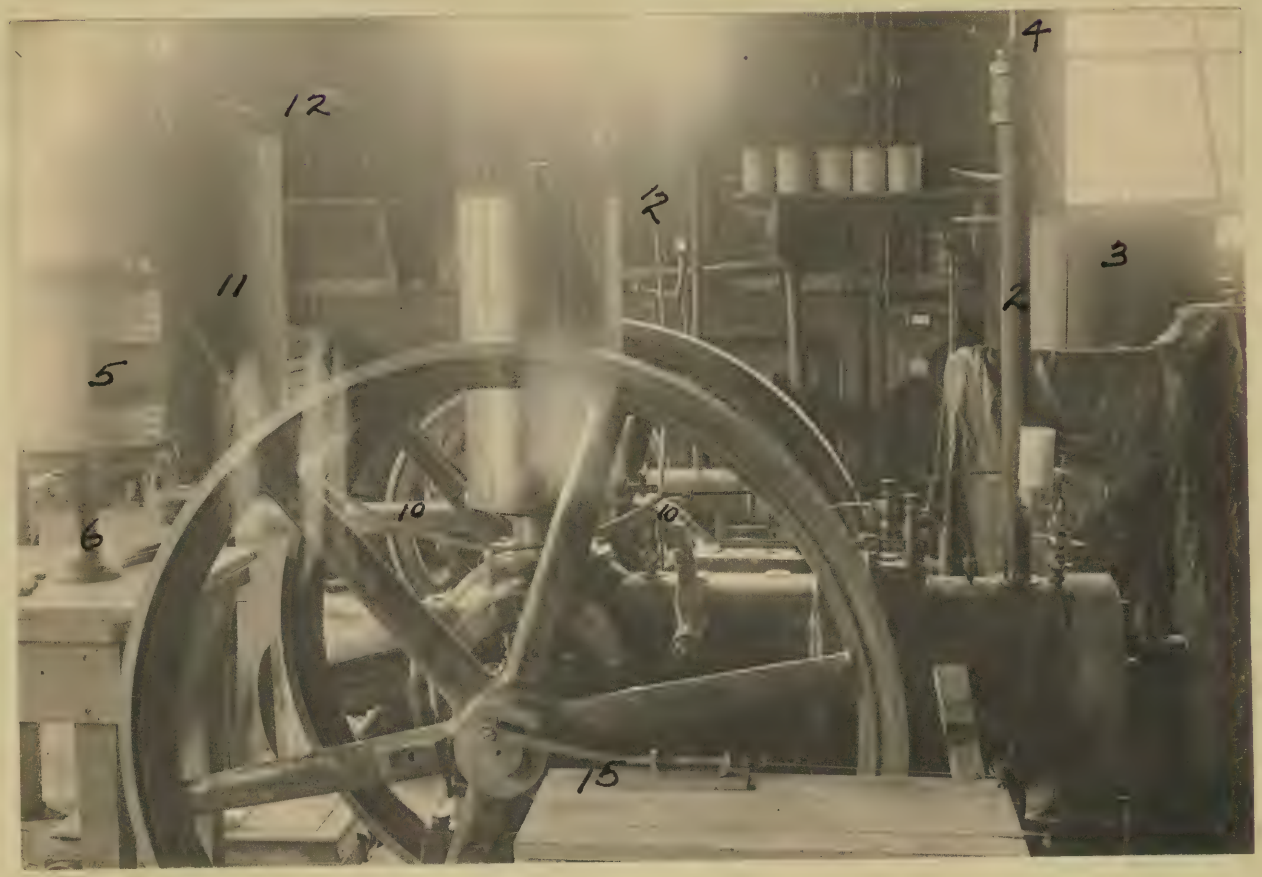
SECOND:- Compressing this charge in the crank case on the return stroke of the piston and forcing the charge into the cylinder.

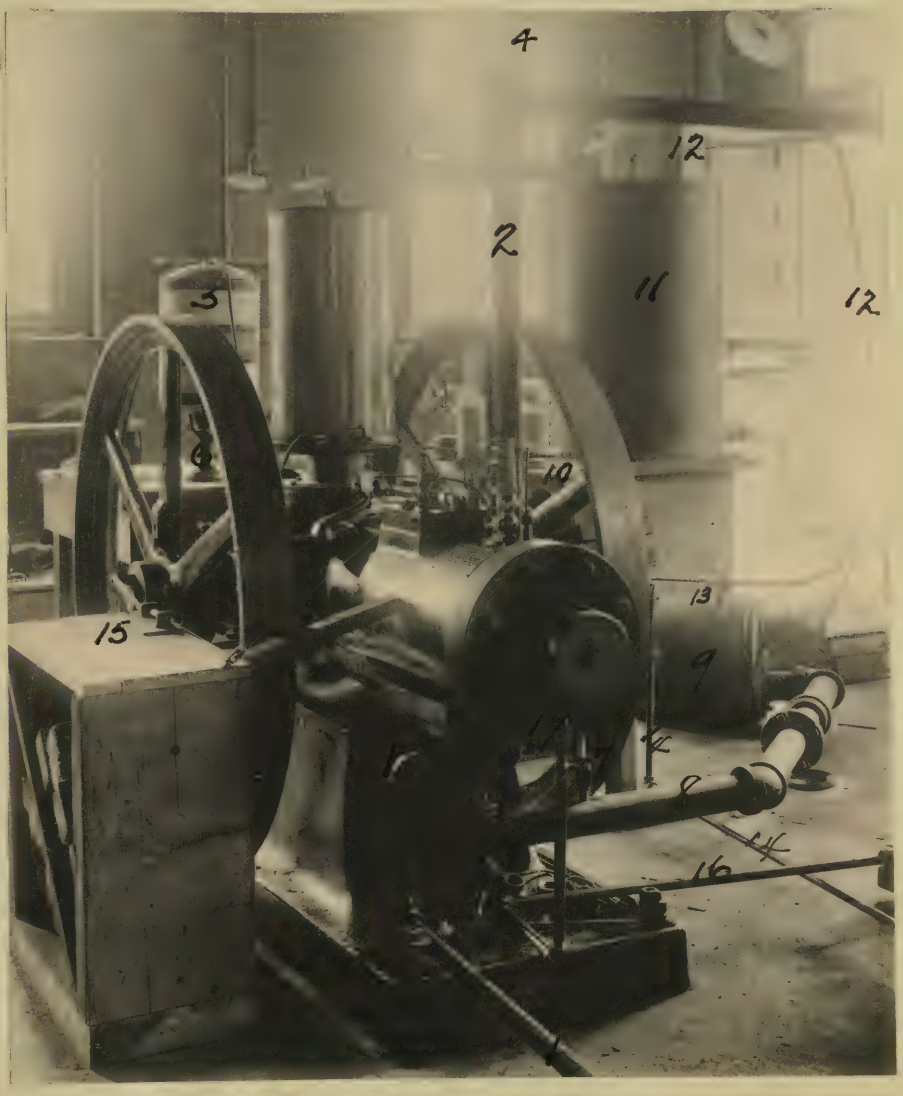
In order that this cycle be carried out actually would require no heat to be taken up or given to the cylinder walls, in other words, the compression of the mixture should be adiabatic, and the expansion of the heated gases should also be adiabatic, a condition of course which is never realized in practice.

On p. 5 - 6 are two views of the engine with instruments used during the tests. The crank shaft carries two fly wheels, which are centre driven from a trunk piston, which with the other reciprocating parts is all enclosed, as shown in Pate I, p. 4.

The main journals are ring oiled as shown at N-N Plate I, p. 4.




4
12
12
3
11
2
5
10
10
6
15


4
12
2
11
12
3
10
13
15
9
16

The temperature of inlet water was taken from thermometer placed in an oil well, not shown in photograph, in the line./.

4. The temperature of discharge water was taken at 4, the weight of water was read with hook gauge in tank 3. The weight of oil consumed during a run was measured by taking a reading of the weight of the oil and can 5 on the scales 6, at the beginning and end of the test. The temperature of the exhaust gases was taken by a thermometer in oil well 7 placed in the exhaust line 8. Thermometers not shown in the picture were used to determine the temperature of the air, of the room and of the oil.

A muffler shown at 9, consisting simply of a hollow cast iron vessel was used in the exhaust line to muffle the sound.

An ordinary prony brake was used to produce the load, shown partly in picture at 10. It consists of a wooden beam and a piece of leather belting, to which wood-

en shoes were attached. The pulley on which the brake was applied was provided with a flanged wooden rim to hold the cooling water.

The cooling water was taken from the tank 11 and conducted by means of the pipe and tubing 12 to the inside of the brake pulley. The flow of water was regulated by the valve 13. The discharged cooling water was conducted from the brake pulley by the line 14.

The load on the brake was measured by means of scales not shown in the picture; the knife edge of the brake arm 10 resting on a strut placed on scales. The brake was oiled well to prevent the shoes from stubbing and thus keeping the load more constant during the run. The zero reading of the brake was determined by the plus and minus method, a mean of a number of readings being taken. A speed counter was used to determine the revolutions per minute.

The indicator was of special design on account of the high pressures developed in the cylinder. The motion

for the indicator was obtained by a specially designed indicator, rigging, shown at 15, so constructed that the ratio of the crank ~~shaft~~ to the connecting rod was the same, as ratio of actual crank to the actual rod, and so that in all positions the two cranks and rods were always in the same plane. This arrangement gave the desired motion.

The special indicator had two pistons whose area ratios were as 2 : 1 approximately.

During the tests the small piston and 100 lb. spring were used. The indicator spring was calibrated on a throttling drum; as the available pressure was only about 100 lbs, the 100 lb. spring was calibrated by using the larger piston in the indicator. The mean scale of the spring determined by the calibration, multiplied by the ratio of the piston areas, equals the scale of the spring as used with the small piston, which was used during the tests. In calibrating the spring, an indicator and gauge were attached to the throttling drum. The pressure was regulated so as to rise by 10 lbs. from 0 to 100 lbs, and

lines were drawn on the indicator card for every 10 lbs. interval on the gauge. Two cards were then taken with increasing pressure and two with decreasing pressure.

In working out the calibration, the gauge was first calibrated on a Crosby Gauge tester giving the calibration curve shown on p.#. 20 . The pressures varying by 10 lbs. were corrected according to the calibration of gauge.

The distance from the 10 lb. line to each of the other pressure lines was measured; by dividing the difference of pressure by the corresponding difference of ordinate, between the 10 lb. line and each of the other lines, we get the values of the scale of the spring, the mean of which for all of the cards gives the true scale of spring as used with the large piston. This when multi plied by the ratio of the piston areas gives the true scale of the spring as used with smaller piston in the test. For tabulated results see p.#. 21 .

All the thermometers used during the test were calibrated in the Physical Laboratory of the University of

Pennsylvania by finding the fixed points, and the readings corrected. For tabulated results see p.[illegible].

The engine is entirely valveless. As the piston returns it creates a vacuum in the Crank Case and when it reaches its forward dead centre it uncovers the inlet port "C" (Plate I). P4. The air from the room now enters at "A" passes through the openings "B" -"B" u the bed plate and thence through the inlet "C" into the crank case "D". On the forward stroke the piston immediately closes the port "C" and begins to compress the air in the crank case, and when the piston approaches the dead centre on the forward stroke it opens the port "F", thus forcing the air under pressure through the passage "E"-"E"-"F" into the cylinder "G" in front of the piston. The piston as seen from the drawing is slightly concave, thus deflecting the scavenging charge admitted from the crank case, as indicated by the arrows and forcing a portion of the burned gases into the atmosphere. At the same time the piston is returning the exhaust port is being slowly closed while a fresh

charge of air is being admitted through the port "F", and mixed with a charge of kerosene, forced in by the plunger pump under the action of the governor (See description p.p.13-14-15-16) The whole charge being compressed by the moving piston.

When the highest point of compression is reached a charge of the kerosene flowing in, under the action of the governor and plunger pump, falls on the hot lip "K" of the igniter ball "L" and vaporizes, the mixture exploding and impelling the piston towards the other end of its stroke, when the exhaust port "H" opens and part of the burned gases escape into the atmosphere.

The engine was started by heating the igniter ball "L" with illuminating gas taken from the city mains and conducted through the line 16 to the jet 17. When the igniter ball is hot enough to vaporize the kerosene and ignite the charge, the jet was turned off, the heat of compression keeping the ball almost a bright red.

The cylinder is water jacketed to prevent overheat-

heating. Water enters the cylinder jacket at 1 from the tank in the attic and is discharged through the pipe ~~two~~ 2 into the tank ~~three~~ 3 which was calibrated to read the weight of water directly by means of a hook gauge. See photograph p.#. 5 ~~also plate I~~.

The clearance volume of the engine was determined by placing the piston on its ~~forward~~ Head ~~dead~~ centre and filling the combustion chamber and igniter ball space with water. From the known weight of water required, and its temperature, the volume of the space occupied was calculated. For tabulated results see p.#. 23 .

The speed of the engine is regulated by a centrifugal shaft governor. See Plate 3, p.#. 14 . "A" is the governor pivoted on the arm of the fly wheel at "B" and pivoted to the eccentric at "C". The other end of the governor is supported by a spring "D", the tension of which can be adjusted by means of the nuts 1 -1 and check nut 2. The spring is connected at one end to the threaded hook "F" and at the other end is fastened permanently

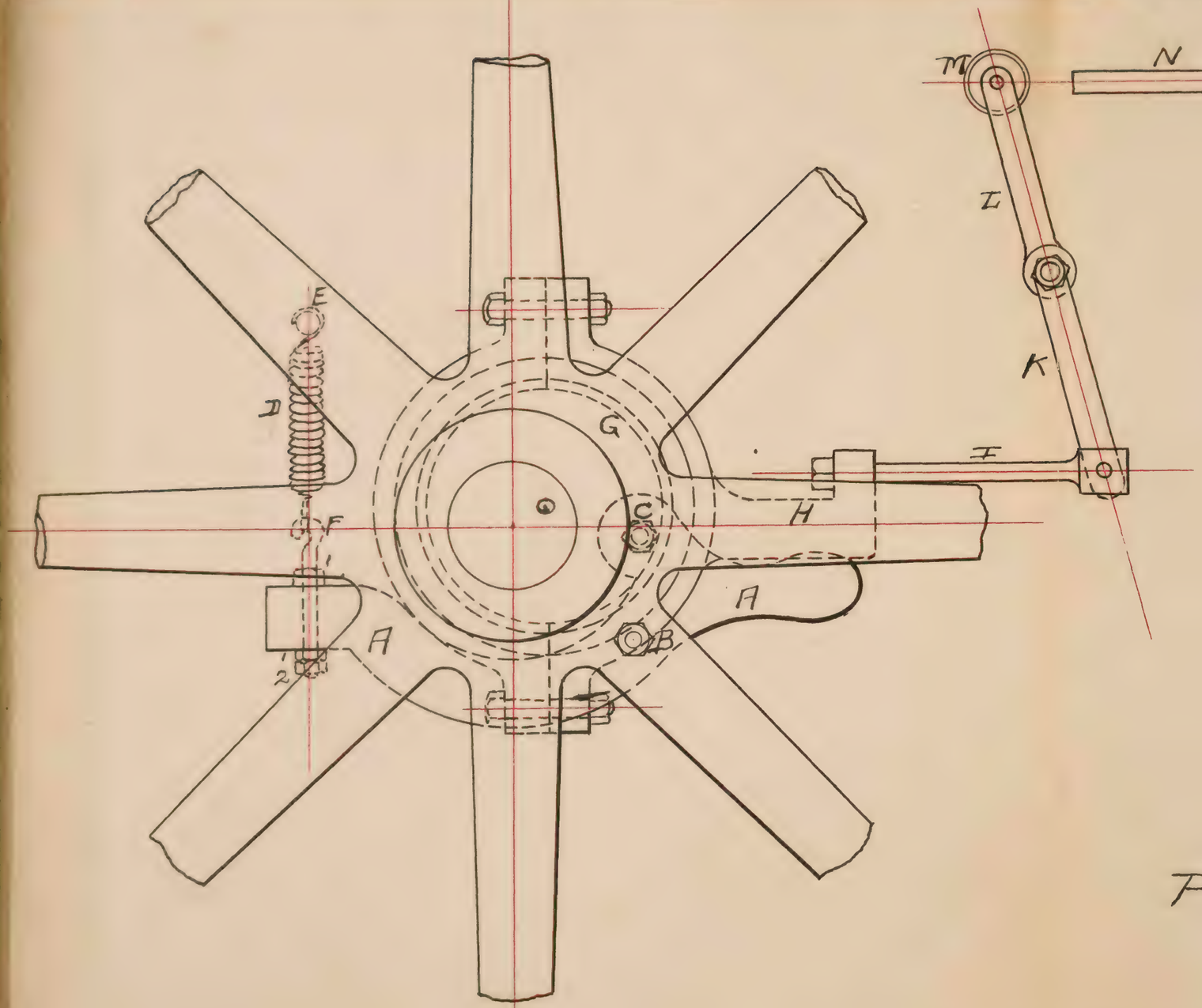
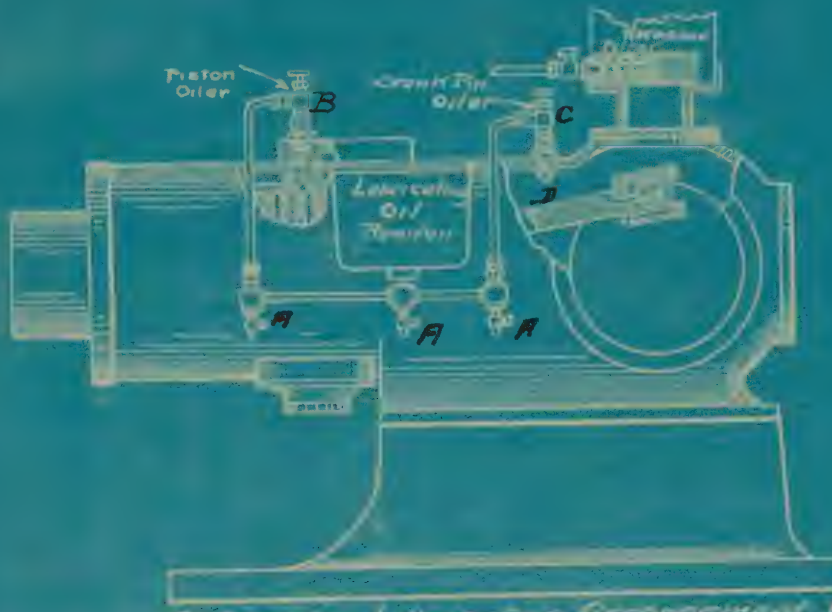


Plate-3.

to pin "E" on the arm of the fly wheel. "G" is the eccentric with strap and its projection H. "I","K", "L" are the connecting links by means of which the eccentric is made to act on the pump. "M" is a roller, turning on the spindle "P", and which strikes the rod "N" of the plunger pump, which supplies the charge of kerosene.

As the engine speeds up the governor is thrown out under the action of the centrifugal force, which causes the point "O" to travel nearer the centre, thus diminishing the eccentricity and stroke of the eccentric. This reduces the stroke of the pump and thus diminishes the supply of kerosene, until the engine again regains its normal speed. The governor thus regulates the speed of the engine between no load and full load.

The arrangement for lubricating the piston and crank pin is entirely automatic, as seen by plate II p.ø. 16 . "A"-"A"-"A" are drip cocks in the brass line connected to the oil reservoir. "B" and "C" are valves provided at their bottom with small checks, which



Automatic Lubricating Arrangement for Piston and Crank Pin

Plate II

open downward under vacuum. The vacuum created under the forward stroke of the piston allows the check in"C"to open, thus permitting the oil to drop on the connecting rod. The rod is grooved for a considerable portion of its length as shown in the drawing, the oil thus finding its way through the groove to the crank pin. The piston is oiled in a simiiliar manner, the stroke of piston which creates the vacuum to open the check "C" also furnishes the vacuum to open the check in "B", the oil finding its way to the piston as indicated. A piece of iron tubing fitted into the piston as a forcing fit and directly over the wrist pin acts as a wiper to take up the oil as the piston sweeps by the opening of the oil inlet, and so lubricating the wrist pin. The check "B" therefore serves the double purpose of allowing the oil to lubricate the piston and also the wrist pin.

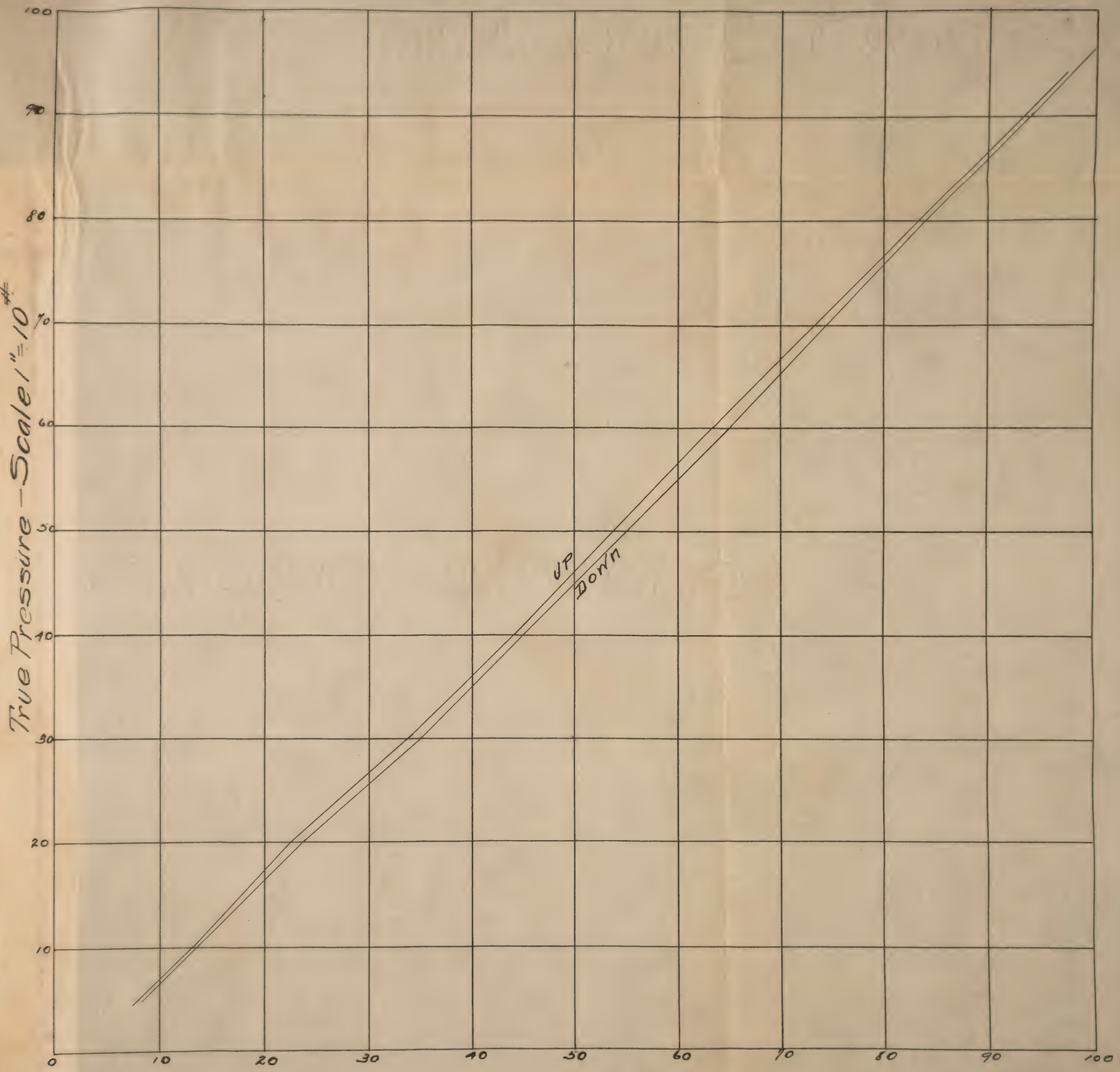
The kerosene oil is conducted to the combustion chamber in the following manner:-

I is a spring which causes the pump plunger to recede when it is not under the action of the governor. 4 is a suction or vacuum check. 5 is a pressure check, while 7 and 8 are each vacuum checks. As the plunger re-

cedes, a vacuum is formed in the chamber 6, around it, and the suction check 4 opens allowing the kerosene to flow in and take its place, as the plunger is thrust forward under the action of the governor the pressure closes the check 5, ~~allowing~~ forceing the kerosene ~~to find its way~~ through the double check 7 - 8. 3 is a hand lever to pump in a charge by hand on starting.

Results of Tests
Mietz and Weiss
Kerosene Engine
University of Pennsylvania
1903

L. C. Manz.



Guage Pressure

Calibration Curve of Steam Guage No. 184936

Calibration Indicator Spring — Ascending Pressure

Guage Press	True Press	Press Diff.	Diff. of Ordinate Card 1	Diff. of Ordinate Card 2	Mean D. of Ord.	Scale
90	86.5	79.5	.81	.82	.815	97.5
80	74.4	67.4	.726	.740	.733	92.1
70	66.8	59.8	.620	.624	.622	96.1
60	56.8	49.8	.496	.514	.505	98.5
50	46.0	39.0	.392	.400	.396	98.3
40	36.0	29.0	.290	.300	.295	98.1
30	26.7	19.7	.180	.195	.1875	106.0
20	17.2	10.2	.100	.100	.100	102.0
10	7.0					

Calibration of Indicator Spring — Descend Press.

90	86	79.6	.81	.82	.815	97.8
80	75.8	69.4	.762	.760	.761	91.1
70	65.0	58.6	.630	.630	.630	93.1
60	55.0	48.6	.516	.510	.513	94.8
50	44.9	38.5	.410	.413	.4115	93.4
40	35.0	28.6	.310	.310	.310	92.3
30	25.6	19.2	.20	.20	.200	96.0
20	16.4	10.0	.10	.10	.100	100.0
10	6.4					

Mean Scale 96.69

The diameters of the two pistons of the indicator were measured with a micrometer screw and found to be

Diameters .796" — .564

Areas .4976" — 2498"

Scale of piston assumed during the test —

$$96.69 \times \frac{.4976}{.2498} = 192.7$$

Calibration of Steam Guage

189436 — Used in Calibrating Indicator Spring

True Press	Guage Ascend	Guage Descend	True Press	Guage Ascend	Guage Descend
10	13	13.6	60	63.1	65.1
20	22.5	23.6	70	73.6	74.5
30	33.8	35.0	80	83.2	84.0
40	44.0	45.0	90	93.5	94.0
50	53.8	55.0	100	103	104

For Calibration Curve of Guage

See pp. 20

Clearance Volumne of Engine

Weight Full	Weight Empty	Net Weight	Tempt Water	Vol. of Water Req'd
4# 6 1/2 oz	1# 2 1/2 oz	3# 4 oz	88°F	.05242 cu ft.
4" 7 oz	1# 2 1/2 oz	3# 4 1/2 oz	87°F	.05292 cu ft
				.05267 cu ft

Volumn of Cylinder

$$\frac{8 \times 38.484}{1728} = .1781 \text{ cu ft}$$

$$\% \text{ Clearance} = \frac{.05267}{.1781} = 29.6\%$$

Specific Gravity determination of the Kerosene

Wt of flask and 100 cc Kerosene = 100 Gm

Wt of flask = 32.48 Gm

Wt of 100 cc of Kerosene = 77.52 Gm

Sp Gravity = .7752

$$\frac{48.41}{7.48 \times 8} = .809 \text{ lbs per pint}$$

Wt of a cu ft Kerosene = 48.41#

Note:- The above determination is at Tempt 88°F

Test No1 No Load May 23 - 1903.

Time	Temp Inflow	Temp outflow	Temp Exh	Wt Water Begin	Wt Water End	Wt Oil Begin	Wt Oil End	Brake Load	R.P.M	Bar Begin	Bar End	Temp Oil
10-49-10	82	96		145		29#-14 3/8 oz		46	360	30.02		88°
10-55-0	82	97	366					48	361			88°
11-0-0	82	98	366					48	360			88°
11-5-0	82	99	366					48.5	359			88°
11-10-0	82	100	374					48	360			88°
11-15-0	82	100	376					48	360			88° F
11.21-0	82				720		27#-13 oz	Mean	360		30.026	

Total Load:- 46
48
48
48.5
48
48
6/286.5
Mean = 47.75

Tempt air Room
80° F

Dead Load:-
45.75
46.75
46.00
46.50
4/285.00
Mean = 46.25

Net Load:- 47.75 - 46.25 = 1.50

Test No1 - No Load May 23 1903

Time	Area	length	M.E.P.	Mean Ord	Spring Scale
10.52	.12	3"	7.708	.0400	192.7
11.00	.15	3	9.635	.0500	192.7
11.10	.19	3	12.198	.0633	192.7
11.15	.21	3	13.489	.0700	192.7
11.20	.23	3	14.766	0766	192.7

Mean = 11.559

Engine Constant $= K = \frac{LA}{33000}$

$\frac{8 \times 38.4846}{33000 \times 12} = .0007778$

Brake Constant $= K' = \frac{2\pi l}{12 \times 33000}$

$= \frac{2\pi \times 63}{12 \times 2 \times 33000} = .0004995$

Length of Brake Arm $= 31\frac{1}{2}$"

Results of Test 1 May 23-03

IHP = K x MEP x RPM

= .0007778 x 11.55 9 x 360

= 3.235

BHP = K' x R.P.M x P

= .0004995 x 360 x 1.50

= .2697

FHP = 3.235 - .2697 = 2.9653

Kerosene per IHP. hr.

$$\frac{3.961}{.809 \times 3.235} = 1.514 \text{ pints}$$

Pounds of fuel per hr = 3.961

Kerosene per BHP hr.

$$\frac{3.961}{.809 \times .2697} = 18.15$$

Test No 2 ¼ Load May 23-1903

Time	Temp Inflow	Temp outflow	Temp Exh.	Wt Water Begin	Wt of Water End	Wt Oil Begin	Wt Oil End	Brake Load	R.P.M	Bar. Begin	Bar. End
11-37-45	82	104	413	150		26# 14 3/4 oz		57	355	30.05	30.08
11-45-0	82	105	422					57	355		
11-50-0	82	106	429					57	355		
11-55-0	82	108	436					57	355		
12-0-0	82	120	462					57	355		
12-6-30	82	120	466		568		24# 7 oz	57	355		

Total Load:- 57 lbs

Dead Load:-

45.6
45.4
45.8
45.3
45.4
5 | 230.5
Mean 46.1

Net Load:- 57 - 46.1 = 10.9

Temp't air Room 80° F

Temp't oil 88° F

Test No 2. ¼ Load May 23-1903

Time	Area	length	M.E.P.	Mean Ord	Spring Scale
11-40	.23	2.9	15.28	.0795	192.7
11.45	.13	2.9	8.634	.0448	192.7
11.50	.18	2.9	11.95	.0620	192.7
11.55	.12	3.0	7.708	.0400	192.7
12.00	.09	3.0	5.781	.0300	192.7
12.05	.30	3.0	19.27	.1000	192.7

Mean 11.437

Results of Test 2 May 23-1903

$I.H.P. = K \times M.E.P. \times R.P.M.$

$= .0007778 \times 11.437 \times 355$

$= 3.155$

$B.H.P. = K' \times R.P.M. \times P$

$= .0004995 \times 355 \times 10.9$

$= 1.933$

$F.H.P. = I.H.P. - B.H.P. = 3.155 - 1.933 = 1.222$

Mechanical Efficiency

$$\frac{1.933}{3.155} = 61.28\%$$

Kerosene per IHP hr:-

$$\frac{5.185}{3.155 \times .809} = 2.032 \text{ pints}$$

Wt of Oil used per hr:- 5.185 lbs

Kerosene per BHP hr:-

$$\frac{5.185}{1.933 \times .809} = 3.316$$

Test-No3- Half Load

May-30-1903

Time	Area	length	Mean Ord	M.E.P.	Spring Scale
9.56	.31	3.00	.1033	19.90	192.7
10.02	.37	3.00	.1233	23.75	192.7
10.06	.37	3.00	12.33	23.75	192.7
10.11	.32	3.00	.1066	20.50	192.7
10.16	.35	3.00	.1166	22.42	192.7
10.21	.32	3.00	.1066	20.50	192.7

Mean 21.803

Test-No3-Half Load May 30 - 1903.

Time	Temp Inflow	Temp outflow	Temp Exh	Wt Water Begin	Wt Water End	Wt Oil Begin	Wt Oil End	Brake Load	R.P.M.	Bar. Begin	Bar. End	Temp Oil	Temp air
9-52-45	74	83	497	90#		32-13½		68½	353	30.02	30.026	88	82
10-0-0	75	84	502					68½	354			—	82
10-05	75	84	506					68½	356			—	82
10-10	75	84	510					68½	355			—	82
10-15	75	84	510					68½	355			—	82
10.20	75	84	510					68½	356			—	82
10-21-15					1380		30-5 oz	68½				88	82

Mean = 354.83

Total Load = 68.5 lbs

Net Load:- 68.5 - 45.52 = 22.98

Dead Load:-

45.4
45.7
45.5
45.4
45.6
5)227.6
Mean = 45.52 lbs

Results of Test No3 May 30-03

IHP = K x R.P.M. x M.E.P.

= .0007778 x 354.83 x 21.803

= 6.019

BHP = K' x R.P.M x P

= .0004993 x 354.83 x 32.98

= 4.073

Mechanical Efficiency:-

$$\frac{4.073}{6.019} = 67.67\%$$

FHP = IHP - BHP = 1.946

Kerosene per IHP hr:-

$$\frac{5.329}{6.019 \times .809} = 1.094 \text{ pints}$$

Wt of oil used per hr:- 5.329 lbs

Kerosene per BHP hr:-

$$\frac{5.329}{4.073 \times .809} = 1.617 \text{ pints}$$

Test No 4 Full Load May-30-1903

Time	Temp inflow	Temp outflow	Temp Exh	Wt Water Begin	Wt Water End	Wt Oil Begin	Wt Oil End	Brake Load	Bar. Beg.	Bar. End	Temp Room	Temp Oil	R.P.M
11-10-20	75	81	549	90#		28#-1½		86.25	30.022	30.096	80	88	
11-15	75	81	550					86.25			80		345
11.20	75	81	578					86.00			80		343
11.25	75	81	628					86.00			80		342
11-26-45	75	81			1095		26#-10⅜				80	88	

Engine Stopped 11-26-45 Mean 86.12 Mean 343.3

Total Load = 86.12 lbs

Net Load: —

86.12 − 46.25 = 39.87

Dead Load: —

45.75
46.75
46.00
46.50
4 | 185.00
Mean = 46.25 lbs

Test No 4 Full Load May 30 1903

Time	Area	length	Mean Ord	M.E.P	Spring Scale
11.16	.37	3.00	.1233	23.75	192.7
11.21	.48	2.98	.1610	31.03	192.7
11.26	.40	300	.1333	25.69	192.7

Mean 26.82

Results of Test No 4 May 30-03

IHP = K x RPM x M.E.P.

= .0007778 x 343.3 x 26.82

= 7.161

BHP = K' x R.P.M x P

= .0004995 x 343.3 x 39.87

= 6.843

Mechanical Efficiency:—

$\frac{6.843}{7.161}$ = 95.5 %

FHP = IHP - BHP = .318

Kerosene per IHP hr:-

$$\frac{5.339}{7.161 \times .809} = .9201 \text{ pints.}$$

Wt of Oil used per hr:- 5.339 lbs

Kerosene per BHP hr:-

$$\frac{5.339}{6.843 \times .809} = .9644 \text{ pints}$$

Test No 5 Full Load June 5-03

Time	Area	length	Mean ord	M.E.P.	Spring Scale
10.30	.33	3.00	.110	21.19	192.7
10.35	.41	2.98	.138	26.59	192.7
10.36	.38	2.98	.128	24.66	192.7
10.40	.40	3.00	.133	25.63	192.7
10.45	.38	2.98	.128	26.59	192.7
10.54	.37	3.00	.123	23.70	192.7

Mean 24.72

Results of Test No 5 Full Load

IHP = K x R.PM x M.E.P.

.0007778 x 343.3 x 24.72

= 6.601

BHP = K' x R.PM x P

= .0004995 x 343.3 x 39.75

= 6.816

Wt of oil used per hr:- 5.576 lbs.

Kerosene per IHP hr:-

$\frac{5.576}{6.601 \times .809}$ = 1.044 pints

Kerosene per BHP hr:-

$\frac{5.576}{6.816 \times .809}$ = 1.001 pints.

Test No 5 Full Load June 5 1903 (Gas Analy's)

Time	Temp inflow	Temp outflow	Temp Exh	Wt Water Begin	Wt Water End	Wt Oil Begin	Wt Oil End	Broke Load	Bar. Begin	Bar End	Temp Room	Temp Oil	R.P.M.
10-27-10	72°	84°	500°	90#	915#	24#-14 5/16		86	30.312	30.304	77	88	349
10-33	72°	86°	500°					86			—	—	343
10.38	72°	88°	544°					86			—	88	343
10-44	72°	89°	545°					86			—	—	344
10-48	72°	90°	568°					86			—	—	343
10-53	72°	91°	594°					86			—	88	340
10-57	72°	92°	630°					86			—	—	
10.56							22-3 7/16				77	88	

Mean 343.3

Total Load:- 86 lbs

Net Load:- 86 - 46.25 = 39.75 lbs

Dead Load:- 46.75
46.75
46.00
46.50
4)185.00
46.25

Exhaust Gas Analysis.

Orig. Vol.	After KOH	After Bromine	After Pyro	After $CuCl_2$
100	94.3	94.3	82.3	74.2
100	94.6	94.6	82.7	74.5

Per Cent Volume

Gas	CO_2	Hydro carbons	O	CO	N
100	5.7	0	12	8.1	
100	5.4	0	11.9	8.2	
Mean	5.55	0	11.95	8.15	74.35

	% Vol		Rel. Mol. Density	Rel Wts	% Wts
CO_2 —	5.55	× 22	=	122.1	8.31
O —	11.95	× 16		191.20	13.02
CO —	8.15	× 14		114.10	7.703
N —	74.35	× 14		1040.90	70.90
				1468.30	100.01

Calculating of R of the Exhaust Gases.

Gas	%oWts	C_p	B.T.U.	C_v	B.T.U	$\frac{C_p}{C_v}$
CO_2	8.317	.2012	.01673	.1548	.01288	1.357
CO	7.773	.2426	.01498	.1729	.013444	1.408
O	13.02	.2175	.02832	.1551	.02009	1.408
N	70.90	.2438	.17280	.1729	.1226	1.410
			.23283		.16901	

$R = (C_p - C_v)\,778 = (.23283 - .16901)\,778$

$= 49.65$ ft-lbs.

Note:- The values of C_p and C_v were taken from Smithsonian Tables and Kent's Engineer's Hand Book.

Carbon in a pound of the Exhaust Gas

CO_2 — $8.317 \times \frac{12}{44} = 2.268\%$

CO — $7.773 \times \frac{12}{28} = 3.331\%$

5.599%

Oxygen in a pound of the Exhaust Gas

CO_2 — $8.317 \times \frac{32}{44} = 6.048\%$

CO — $7.773 \times \frac{16}{28} = 4.441\%$

O — 13.02×1 $= 13.02\%$

23.509%

Test No 6 Full Load June 11-03

Area	length	Mean Ord	M.E.P.	Spring Scale
.51	3.00	.170	32.76	192.7
.52	3.00	.173	33.34	192.7
.51	2.98	.172	33.15	192.7
.51	2.98	.172	33.15	192.7
.52	3.00	.173	33.34	192.7
.48	2.98	.161	31.02	192.7
.47	2.98	.158	30.45	192.7
.51	3.00	.170	32.76	192.7
.51	3.00	.170	32.76	192.7
.52	3.00	.173	33.34	192.7
.52	3.00	.173	33.34	192.7
.52	2.98	.174	33.53	192.7
.51	2.98	.172	33.15	192.7
.51	2.98	.172	33.15	192.7
.51	3.00	.170	32.76	192.7
.52	3.00	.173	33.34	192.7
46	2.98	.155	29.87	192.7
48	2.98	.161	31.04	192.7

32.57 Mean

Test No 6 Full Load — June 11 – 1903

Time	Temp Inflow	Temp Outflow	Temp Exh	Wt Water Begin	Wt Water End	Wt Oil Begin	Wt Oil End	Brake Load	Bar Begin	Bar End	Temp Room	Temp Oil	R.P.M
11.30	79	98	529	92#		32-4 1/8		86	30.036	30.032	82.5	88	344
11.35	79	99	553					86			—		344
11.40	78	100	556					86			—		344
11.45	77.5	100	558					86			—	88	344
11.50	78	101	560					86			—		344
11.55	79	101	584					86			—		344
12.00	79	101.5	605		925#		29-6 7/8	86			82.5	88	344

Meon 344

Total Load:– 86 lbs

Net Load:– 86 – 46.25
= 39.75 lbs

Dead Load:–

45.75
46.75
46.00
46.50
184.00
46.25

Results of Test 6 June 11 1903

IHP = K x RPM x M.E.P.

= .0007778 x 344 x 32.57

= 8.714

BHP = K' x RPM x P

= .0004995 x 344 x 39.75

= 6.830

Mechanical Efficiency:-

$\frac{6.830}{8.714} = 78.37\%$

FHP = IHP − BHP = 1.884

Wt of Oil used per hr:- 5.750 lbs

Kerosene per IHP hr:-

$\frac{5.750}{8.714 \times .809} = .8136$ pints

Kerosene per BHP hr:-

$\frac{5.750}{6.830 \times .809} = 1.064$ pints

Summary of Tests.

	IHP	BHP	Mech. Eff.	Oil per IHP hr	Oil per BHP hr
Test I (No Load)	3.235	.2697	—	1.514	18.15
Test II (Quarter Load)	3.155	1.933	61.28%	2.032	3.316
Test III (Half Load)	6.019	4.073	67.67%	1.094	1.617
Test IV (Full Load)	7.161	6.843	95.55%	.9251	.9644
Test V (Full Load)	6.601	6.816	—	1.044	1.001
Test VI (Full Load)	8.714	6.830	78.37%	.8156	1.064

A
B

CONCLUSIONS:- Considerable difficulty was experienced at first in running the tests at full load, the engine stopping after about a fifteen minute run and refusing to pull the load. It was at first thought that the cylinder became overheated, causing premature explosion, which could be seen from card taken shortly before the engine stopped. Pipe connections were changed and all arrangements made for a larger supply of jacket water, to which the engine at first responded well. But after throttling down the supply it was found that the quantity of cooling water which had previously been used was entirely adequate and that the engine had probably been overloaded.

On page 4 is given a summary of tests which show quite a variation in the mechanical efficiency. I believe this is due to the unreliability of the indicator cards, the mean effective pressure of which as seen from the tests varying over a wide range. This condition of affairs is present to a greater or less extent in all

internal combustion engines.

It was at first thought that the cause could be attributed to the engine missing an explosion now and then, and therefore that the number of explosions per minute was not equal to the number of revolutions per minute. An attempt was made to verify this conclusion by disconnecting the muffler in the exhaust line and allowing the engine to exhaust directly into the atmosphere. It was found, that unlike many internal combustion machines the engine rarely or never missed an explosion; it was observed nevertheless that the explosions were sometimes early, sometimes late, and in this, I think we have the real solution.

If a card be taken at the instant the engine has an early explosion we get the card "A", while if a card be taken when the engine explodes late we have the card "B", the areas of which vary quite a little. See P. 45. The same is true of other cards taken under similiar conditions, consequently the mean effective pressure and those quantities

such as the I H P and mechanical efficiency which are directly dependent upon it, must vary. I therefore conclude that in order to obtain any fair idea of the mechanical efficiency of this or any other internal combustion engine, is to take as many cards as possible, thus giving a fairer average of M.E.P. and those quantities directly affected by it. For this reason I consider Test VI the best of the tests run at full load, since here an attempt was made to take as many cards as possible, without any time limit, during the run.

Test V is practically worthless with the exception of the gas analysis and the calculations resulting therefrom, the number of cards taken being too few to be able to determine anything about the run.

The oil consumption per B.H.P.Hr. given in the table for the various tests is probably the most reliable of all the quantities determined.

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